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Alexander C. Wilson[1,2], Matthias Schwannauer[1], Angela McLaughlin[1], Fiona Ashworth[3] and Stella W. Y. Chan[1]

[1] Section of Clinical Psychology, University of Edinburgh, Edinburgh, UK

[2] Department of Experimental Psychology, University of Oxford, Oxford, UK

[3] Department of Psychology, Anglia Ruskin University, UK

Correspondence to: Stella W. Y. Chan, Section of Clinical Psychology, University of Edinburgh, Edinburgh, UK

stella.chan@ed.ac.uk

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Abstract

Lang's bio-informational theory of mental imagery proposes that mental imagery and external stimuli engage emotional information-processing systems in similar ways. However, the positive and negative systems are thought to be distinct, so this similarity is likely to show a valence-specific effect. Therefore, we hypothesised that an individual's ability to construct vivid positive, but not negative, mental imagery would predict positive emotional responding to positive visual stimuli, independently of depressive symptoms. Our stimuli were pictures collected through Project Soothe for possible use in psychotherapy (www.projectsoothe.com); since these pictures were intended to induce soothing emotion, we hypothesised that theoretically-linked variables Self-compassion and Self-criticism would also predict positive responding to the stimuli. A total of 214 participants completed an online study including validated questionnaire measures, mental imagery tasks, and a picture-rating exercise. Only Positive Imagery Vividness and Self-compassion were significant predictors of positive responding to the soothing pictures, even controlling for depressive symptoms, and Negative and General Imagery Vividness. These findings support Lang's theory, and provide evidence for individual differences in a positive processing tendency shared across mental imagery-based and perceptual representations. Since this relationship is distinct from depressive symptoms, future imagery-based psychotherapies might aim to influence this positive processing tendency.

Psychological research has indicated that mental imagery is closely connected with emotion, and plays an important role in the development and potentially the treatment of emotional disorders (Holmes, Blackwell, Burnett Heyes, Renner, & Raes, 2016; Holmes & Matthews, 2010). Mental imagery is the simulation of mental representations that subjectively have sensory properties, but have no basis in current sensory stimuli (Kosslyn, Ganis, & Thompson, 2001). Studies have demonstrated that processing events through mental imagery produces greater changes in mood compared to when language is used to process similar events (e.g. Holmes, Lang, & Shah, 2009; Holmes, Mathews, Dalgleish, & Mackintosh, 2006). These findings have encouraged researchers to develop therapies in which individuals self-generate mental imagery as a means of improving mood (Hackmann, Bennett-Levy, & Holmes, 2011).

Lang's (1979) bio-informational theory of emotional imagery offers an influential account of the close relationship between mental imagery and emotion (for recent reviews, see Ji, Burnett Heyes, MacLeod, & Holmes, 2016 and Lang & Bradley, 2010). This theory proposed that the emotional response systems triggered by external stimuli can also be directly activated by mental imagery-based representations. This means that individual differences in the ability to generate vivid emotional mental imagery and in the tendency to react strongly to emotional external stimuli would be expected to be underpinned by the same underlying cognitive processes. While this proposal is theoretically plausible and clinically relevant, empirical studies have not tested this directly.

Another notable absence in current research involves the potential use of positive visual stimuli in psychotherapy. Many studies have evaluated the effectiveness of therapies in which the individual is coached to generate positive mental imagery, typically in response to ambiguous cues (e.g. Blackwell et al., 2015; Renner, Ji, Pictet, Holmes, & Blackwell, 2016). While these therapies yielded promising results, some individuals reported difficulties in

generating images in their minds and subsequently benefited less from such therapies (e.g. Blackwell et al., 2015). In comparison with mental imagery-based therapies, there has been limited research into interventions using positive externally-presented stimuli, such as pictures or photographs, even though psychologists have theorised that presenting positive stimuli and using guided mental imagery in therapy may work in similar ways by helping individuals learn to upregulate their mood by attending to positive information (Gilbert, 1992; Hackmann et al., 2011; Singer, 2006). This is consistent with the bio-informational theory of emotional imagery, which predicts that positive stimuli and positive mental imagery engage similar cognitive networks and elicit similar emotional responses (Lang, 1979).

Furthermore, Lang's theory predicts that there is a *specific* relationship between the processing of positive mental imagery and the tendency to respond positively to positive stimuli. This is because positive stimuli (and positive mental imagery) are thought to selectively engage one emotional information-processing system, the appetitive system, while negative stimuli (and negative mental imagery) engage a separate second system, the defensive system. These two systems might be differently calibrated in the same individual, activating distinct memory codes and producing distinct behavioural responses relevant to the valence of the stimulus (Lang & Bradley, 2010). This study therefore hypothesised that an individual's ability to construct positive mental imagery would predict positive responding to visually-presented positive stimuli, given that both processes are likely to activate the same positive system and be facilitated by the accessibility of positive information. By contrast, it was hypothesised that positive responding to positive stimuli would be unrelated to the ability to construct negative mental imagery, since these two processes would be expected to activate two distinct information-processing systems, consistent with previous research that has found that generation of positive and negative mental imagery are relatively unrelated (Blackwell et al., 2013).

While we hypothesised that the ability to construct vivid positive mental imagery would predict positive responding to positive stimuli in a valence-specific way, there was a possibility that individuals who experience more vivid mental imagery, whatever the valence, would show stronger responses to external stimuli, therefore indicating a general effect of arousal. Indeed, Cui, Jeter, Yang, Montague, and Eagleman (2007) found that individual differences in self-reported imagery vividness correlated with BOLD signal change in sensory cortex (r = .73), suggesting that mental imagery vividness relates to general perceptual clarity. The present study sought to assess mental imagery vividness as a multifactorial construct (including General, Positive, and Negative Imagery Vividness) to unpick whether any relationship between mental imagery and emotional responding to external stimuli is general or valence-specific.

Project Soothe

Given the potential clinical applications, it is especially important to explore the relationships between mental imagery processing and emotional responding to external stimuli for *positively-valenced* stimuli. The present study focussed on stimuli collected through Project Soothe (http://www.projectsoothe.com), our ongoing citizen scientist research project that seeks to create a bank of soothing pictures for clinical use by inviting members of the public to contribute pictures that make them feel soothed. Soothing is an important concept in Gilbert's model of compassion (Gilbert, 2009). Soothing describes a positive emotion of calm and wellbeing, which is thought to be increased by an individual's tendency to be compassionate towards themselves, but decreased by a tendency to be self-critical (Gilbert, 2009). In Compassion Focused Therapy, Self-compassion has been found to be positively associated with the experience of soothing emotion, while Self-criticism has shown a negative association with soothing emotion, (Gilbert, Baldwin, Irons, Baccus, &

Palmer, 2006; Gilbert & Irons, 2004; Judge, Cleghorn, Gilbert, & McEwan, 2012). In the present study, we were interested in testing the relative strength of the mental imagery variables by comparing them to these emotional response tendencies (Self-compassion and Self-criticism) as independent predictors of positive emotional responses to Project Soothe pictures. Finally, depressive symptoms were likely to predict reduced positive responses to positive stimuli, in line with previous findings (Dunn, Dagleish, Lawrence, Cusack, & Ogilvie, 2004). As it is a well-established predictor, our research focussed on whether the other variables offered additional power in predicting individual differences in positive responding to Project Soothe pictures over and above any effects of depressive symptoms.

Hypotheses

In summary, it was hypothesised that mental imagery variables, Positive Imagery Vividness and General Imagery Vividness, and Self-compassion would predict increased positive responses to Project Soothe pictures, while Self-criticism would predict reduced positive responses. It was hypothesised that these effects would be apparent even after controlling for depressive symptoms. Negative Imagery Vividness would not contribute to the model.

Method

Design and ethics

This cross-sectional study recruited individuals to complete self-report measures, undertake imagery tasks, and rate pictures collected as part of Project Soothe, in an online survey. This study received ethics approval from the University of Edinburgh Research Ethics Committee. An incentivising lucky draw of £30 was offered.

Participants

A total of 214 participants were recruited via social media and posts on websites publicising social research studies. The only inclusion criterion was age 16 or above. The majority was female (n=143, 66.8%). Age ranged between 16 and 74 years (M = 27.03, SD = 11.66). The sample was predominantly White (n = 176, 82.2%), with 16 self-identified as Asian (7.5%), 10 Hispanic or Latino (4.7%), seven Black (3.3%), and five mixed-race (2.3%). A subgroup of participants (n=37, 17%) reported current symptoms indicating possible depression based on their Patient Health Questionnaire (PHQ-9) scores (see below.)

Recruitment was active for a set period of three months, after which our survey was programmed to close and data were subsequently analysed. An *a priori* power calculation conducted in G*Power indicated that 103 participants were required for a multiple regression including three covariates and four predictors to detect a medium effect size (f^2 = 0.15), using an alpha of 0.05 and power of 0.80 (Faul, Erdfelder, Buchner, & Lang, 2013). A medium effect size was assumed based on the medium-sized relationships between imagery vividness and mood reported in the literature (e.g. Blackwell et al., 2015). By recruiting beyond the minimum target, our sample was sufficiently powered to detect effects even if the actual effect sizes were smaller than assumed, while allowing us to conduct any *post hoc* analyses that may be indicated by primary findings.

Procedure and Measures

Questionnaires, mental imagery tasks, and the Project Soothe picture rating exercise were presented by Bristol Online Survey tool. The pictures were presented at the end of the protocol to avoid mood induction effects. The measures were completed in the order presented below.

Patient Health Questionnaire (PHQ-9, Kroenke, Spitzer, & Williams, 2001). Depressive symptoms were measured using this short 9-item scale, which has been well

validated in a meta-analysis reporting an average sensitivity to depression of 81.3% and a specificity of 85.3% (Mitchell, Yadegarfar, Gill, & Stubbs, 2016). Individuals indicated how often in the past fortnight they had experienced various symptoms on a scale of 0 (Not at all) to 3 (Nearly every day). Possible depression is indicated by a score of 2 or 3 on at least 5 items (or 1 in the case of the self-harming/suicidal item), and this must include at least the first item (depressed mood) or the second item (anhedonia) (Kroenke et al., 2001). Cronbach's alpha was .89 in this study.

Forms of Self-Criticizing/Attacking and Self-Reassuring Scale (FSCRS, Gilbert, Clarke, Kempel, Miles, & Irons 2004). This 14-item self-criticizing scale was used to measure Self-criticism. Based on a probe statement (When things go wrong for me...), participants responded to self-critical items (e.g. I am easily disappointed with myself) on a continuous scale from 5 (extremely like me) to 1 (not at all like me). Previous factor analysis has separated Self-criticism into two factors, 'inadequate self' (9 items, $\alpha = .90$) and 'hated self' (5 items, $\alpha = .86$) (Gilbert, Clarke, et al., 2004). However, these subscales have been found to be highly correlated ($r = .73$), and inter-correlated with convergent measures of Self-criticism (Kupeli, Chilcot, Schmidt, Campbell, & Troop, 2013). Owing to this high correlation, which was also replicated in the present study ($r = .79$), the total sum score was used here, in line with research literature (Richter, Gilbert, & McEwan, 2009; Rockliff, Karl, McEwan, Gilbert, Matos, & Gilbert, 2011). Cronbach's alpha was .95 in this study.

Self-Compassion Scale – Short Form (SCS-SF, Raes, Pommier, Neff, & Van Gucht, 2011). Self-compassion was measured using this12-item short form of Neff's Self Compassion Scale (Neff, 2003). In a validation study, the short form and original were nearly perfectly correlated ($r \geq .97$ in three samples), and had a one-factor structure (Raes et al., 2011). Participants indicated whether statements such as 'When I am going through a very hard time, I try to give myself the caring and tenderness I need' correspond to how they

typically behave, on a 5-point scale from 1 (Almost never) to 5 (Almost Always). Cronbach's alpha was .89 in this study.

Vividness of Visual Imagery Questionnaire (VVIQ, Marks, 1973). This measure of General Imagery Vividness required participants to generate 16 neutral mental images according to short verbal prompts (e.g. 'the front of a shop you often go to'). Participants rated the vividness of each mental image on a scale of 5 ('perfectly clear and as vivid as normal vision') to 1 ('no image at all, you only "know" that you are thinking of something'). A review indicated that this widely used measure has satisfactory reliability and good validity (McKelvie, 1995). While the VVIQ is a subjective measure, Cui and colleagues (2007) showed that it correlated with individual differences in activity in primary visual cortex during mental imagery tasks (r = .73), illustrating its construct validity. The measure has been previously used in online studies with good psychometric properties (e.g. Nelis, Holmes, Griffith, & Raes, 2014), suggesting there are no reliability concerns in administering the measure online. Cronbach's alpha was .89 in this study.

Prospective Imagery Task (PIT, Stöber, 2000). This task provided separate measures of Positive Imagery Vividness and Negative Imagery Vividness. Individuals generated mental imagery relating to themselves in hypothetical scenarios, according to 10 explicitly negative (e.g. You will have a serious disagreement with a friend) and 10 explicitly positive statements (e.g. You will do particularly well at work). Participants scored the vividness of each mental image on a scale of 5 (very vivid) to 1 (no image). This measure has been used by participants without the immediate presence of a researcher in numerous high-quality imagery studies (e.g. Blackwell et al., 2013; Holmes, Lang, Moulds, & Steele, 2008), so there were no reliability concerns in presenting it online. Cronbach's alpha in this study were .88 for Negative Imagery Vividness and .89 for Positive Imagery Vividness,

respectively, and the two dimensions were minimally correlated (r = .25), replicating the good psychometric properties documented in the literature (Blackwell et al., 2013).

Positive Responding to Project Soothe Pictures. Participants reported their emotional responses to 50 *soothing* pictures collected through Project Soothe. At the time of the study, Project Soothe had gathered over 500 soothing pictures from members of the public, with the top five themes being landscapes, water features, flowers & trees, animals, and sky. The specific pictures for this study were selected randomly and then presented to participants in the format in which they were submitted, with 10 pictures presented vertically down each of five pages. Example pictures are presented in the Appendix. Participants rated how Soothed, Happy, and Excited, as well as how Anxious (to test for discriminant validity), they felt in response to each picture on a 7-point Likert scale from 1 (not at all) to 7 (very much). Total scores for each of the four emotions were summed for each participant. Soothed, Excited, and Anxious are terms used to describe the feelings associated with the three affective systems, *Soothing, Drive*, and *Threat*, in the Compassionate Mind literature (Gilbert, 2009). Since this study drew from diverse literature with different models of affect, a third measure of positive affect, 'Happy', was used. Having three positive terms meant that emotional responding also conformed to a more conventional model of affect, the circumplex (e.g. Posner, Russell, & Peterson, 2005), with Soothed relating to positive affect with low activation, Happy to medium activation, and Excited to high activation. The term Happy has good construct validity; for instance, Longo's (2015) factor analysis of the positive affect terms of the circumplex model found that 'happy' was the term with the strongest loading onto the factor 'medium positive affect'. Of the three factors ('low positive affect', 'medium positive affect' and 'high positive affect'), 'medium positive affect' explained the most variance in positive affect in this factor analysis, and, importantly, this factor was the only one to significantly predict life satisfaction (r = .82) in Longo (2015); this suggests that

'medium positive affect', for which 'happy' was the most representative term, had high criterion validity.

Data analysis

Analysis was conducted in IBM SPSS Statistics 21. This study was the first to utilise the soothing pictures collected from Project Soothe. As such, paired samples *t*-tests were conducted to verify that these pictures were perceived positively. Ratings for the one negative response term, Anxious ($M = 93.18$, $SD = 43.04$), were significantly lower than for Happy ($M = 186.78$, $SD = 63.17$), $t\ (213) = 20.12$, $p < .001$, $d = 1.76$, Soothed ($M = 174.52$, $SD = 57.82$), $t\ (213) = 19.93$, $p < .001$, $d = 1.61$, and Excited ($M = 139.58$, $SD = 59.72$), $t\ (213) = 11.83$, $p < .001$, $d = 0.90$. All these effect sizes were large (Cohen, 1988), suggesting that participants experienced the pictures as positively-valenced, as intended. Cronbach's alpha was calculated for all questionnaire measures as a safeguard to the validity of responses, given that this was an online study without the immediate presence of the researchers; in all cases, internal consistency was high.

Correlation analysis was used to examine the relationships between the variables, before running multiple regression analysis to ascertain which were the strongest predictors of positive responding to Project Soothe pictures. Nonparametric Spearman's Rank Order Correlations (two tailed) were computed, since some variables (Depression, Self-criticism, and Anxious and Excited ratings of the Project Soothe pictures) were not normally distributed. Multiple regression analysis makes no assumptions regarding normality of variables, only of residuals (Cohen, Cohen, West, & Aiken, 2003), so it was deemed appropriate to continue with our planned multiple regression analysis.

The assumptions of multiple regression were assessed. Examination of residuals statistics revealed no multivariate outliers (using the $z = 3$ guideline, supported by

Mahalanobis's distance and Cook's *D* indices; Osborne & Overbay, 2004). Multicollinearity was checked through Variance Inflation Factors, with 10 taken to indicate a problem (Clark-Carter, 2010); values safely ranged between 1.07 and 3.72. Q-Q Plots and non-significant Shapiro Wilk tests indicated normality of residuals. The only issue that required attention was some moderate heteroscedasticity; this was addressed by using bootstrap sampling 1000 times with replacement, as asymptotically equivalent to using the Huber-White heteroscedasticity correction (Cameron & Trivedi, 2005). Three bootstrapped hierarchical multiple linear regressions were run, one for each criterion variable: Soothed, Happy, and Excited. Step 1 controlled for the covariates Depression, age and gender (entered as a dummy variable); in Step 2, General Imagery Vividness, Positive Imagery Vividness, Negative Imagery Vividness, Self-compassion, and Self-criticism were added to establish whether the predictors explained variance in the criterion variable (Soothed, Happy, or Excited).

Results

Descriptive data and Spearman's correlations are shown in Table 1. General Imagery Vividness and Positive Imagery Vividness were positively correlated with all three positive ratings of the Project Soothe pictures (Soothed, Excited, and Happy). Positive Imagery Vividness showed stronger relationships with positive responding to the pictures than General Imagery Vividness did, to the order of medium compared to small-to-medium effect sizes. Negative Imagery Vividness was not significantly related to positive responding to the pictures (all p's > .05). Self-compassion showed small-sized positive correlations with all three positive ratings of the pictures. These correlations were stronger than those for Self-criticism, which only showed significant negative correlations with the Happy and Soothed ratings, and not for Excited.

The hierarchical multiple regression analyses with Happy, Excited, and Soothed as criterion variable are presented in Tables 2, 3, and 4.

The model for Happy ratings reached significance in Step 1, F (3, 210) = 3.05, p = .030, but these variables (Depression, gender, age) only explained 2.8% of the variance. The variables added in Step 2 (Positive Imagery Vividness, Negative Imagery Vividness, General Imagery Vividness, Self-criticism, and Self-compassion) produced a significant change, F (5, 205) = 9.84, p < .001, with the full model explaining 19.7% of the variance. In the full model for Happy, Positive Imagery Vividness (β = .35, p = .003) and Self-compassion (β = .24, p = .026) were significant predictors.

The model for Excited did not reach significance in Step 1. The addition of the variables in Step 2 was significant, F (5, 205) = 11.63, p < .001, with the full model explaining 20.4% of the variance. In the full model for Excited, Positive Imagery Vividness (β = .39, p < .001), Self-compassion (β = .30, p = .009), and Self-criticism (β = .26, p = .034) were significant predictors.

The model for Soothed did not reach significance in Step 1. The addition of the variables in Step 2 was significant, F (5, 205) = 5.30, p < .001, with the full model explaining 8.8% of the variance. As with the models for Happy and Excited, Positive Imagery Vividness (β = .22, p = .048) and Self-compassion (β = .27, p = .014) were significant predictors in the model for Soothed.

Secondary Analysis

We asked participants to rate to what extent each Project Soothe picture made them feel ‘anxious’. This rating was originally included to verify that pictures were perceived as positive as intended. As such, the Anxious response to the pictures was not analysed for the main hypothesis. However, we noted that Anxious response was significantly correlated with

key variables, and, in particular, showed a stronger correlation with Depression than the positive ratings for the pictures. We therefore ran a bootstrapped hierarchical multiple regression for Anxious response in the same way as for the positive emotions described above. The model for Anxious was significant in Step 1, F (3, 210) = 3.99, p = .009, explaining 7.6% of the variance. The addition of the variables in Step 2 was *not* significant, F (5, 205) = 2.16, p = .060, though the full model remained significant, F (8, 205) = 3.97, p < .001, explaining 10% of the variance. In the full model, only Depression was significant (β = .26, p = .016). Interestingly, of all the mental imagery variables, Positive Imagery Vividness was the only predictor to show a trend towards reaching significance (β = .20, p = .074). Negative Imagery Vividness, which might be expected to predict Anxious response, was not even close to reaching significance level (β = .08, p = .395).

Discussion

Our results extend existing literature by indicating a specific relationship between the ability to vividly generate positive mental imagery and the tendency to respond positively to positive visual stimuli. We also found evidence for a distinct relationship between trait Self-compassion and positive responding to positive stimuli.

To our knowledge, no previous study has examined whether the relationship between mental imagery and perception is especially close when the specific *valence* of mental imagery-based and perceptual representations are taken into consideration. It is noteworthy, therefore, that this study found that positive responding to positive stimuli was *only* predicted by Positive Imagery Vividness, even when Negative Imagery Vividness and General Imagery Vividness were included in the regression models. Our findings support the view that mental imagery processing overlaps with the emotional processing of external stimuli (Holmes & Matthews, 2010). The typical approach to the relationship between mental imagery and the

perception of external stimuli is that both share sensory processing, as indicated by studies of mental imagery and the activation of sensory cortex (e.g. Ganis, Thompson, & Kosslyn, 2004). Our study extends the existing literature by showing that valence is also critical to the relationship between mental imagery and perception, as predicted by Lang's (1979) bio-informational theory of emotional imagery.

The relationship between Positive Imagery Vividness and positive responding to positive stimuli is likely to reflect individual differences in the calibration of a general positive affect processing system, as suggested by Lang (1979). Explaining this further, we suggest that our test of Positive Imagery Vividness (the positive items of the PIT) indexed the accessibility of positive representations in memory. Thus, a person with a higher score on this test would be more likely to retrieve positive information when presented with the Project Soothe pictures, thereby promoting their positive affective response. It is also possible that individuals high in Positive Imagery Vividness were more inclined to become imaginatively involved in the pictures; this suggestion is supported by the fact that the PIT specifically measures *prospective* imagery (i.e. simulations of possible future scenarios). An individual's vividness of positive *prospective* imagery has been previously associated with optimism (Blackwell et al., 2013; Ji, Holmes, & Blackwell, 2017), and in the context of our study, it is plausible that participants high in Positive Imagery Vividness had greater access to positive future-oriented representations of the world that encouraged them to "step into" the Project Soothe pictures. To further evaluate this idea, it would be interesting to test whether the vividness of *prospective* mental imagery, rather than valenced mental imagery *per se*, is critical to the relationship we found. Our study provides some suggestive, though not definitive, support for this idea, given that the VVIQ, which does include some positive items (e.g. imagining a sunset), did not predict responses to the positive pictures when taking into account other variables. Meanwhile, the lack of a relationship between Negative Imagery

Vividness and positive responding to positive stimuli supports the view that processing positive mental representations is distinct from negative processing, as Lang's theory of two separate emotional systems predicted. Therefore, our results contrast with the intuitive idea that an individual with higher Negative Imagery Vividness would have lower positive responses to positive stimuli. However, the notion that positive and negative processing are dissociable is in line with the influential two-factor structure of emotion (Watson & Tellegen, 1985), in which positive and negative emotion are separate dimensions.

Self-compassion also predicted positive responding to Project Soothe pictures across all the regression models, significant even when controlling for depressive symptoms. This effect was distinct from the relationship between Positive Imagery Vividness and positive responding, which is taken to indicate accessibility of positive information, and therefore suggests that a disposition to be accepting and non-judgmental towards the self independently predicted greater positive responses to positive stimuli. This is in line with Gilbert's (2009) theory that Self-compassion predicts a greater tendency to experience soothing emotion. Gilbert (2009) also suggested that greater Self-criticism is associated with reduced positive responding to external stimuli, although in our results Self-criticism was a weaker predictor than Self-compassion. We speculate that this is because Self-compassion involves a proactive relationship between the self and the outside world aimed at promoting well-being (Neff, 2003). While the focus of theories of Self-compassion has been on acceptance of adversity, it is plausible that this also includes a tendency to be receptive towards positive stimuli, especially given that one of the three core components of Self-compassion is kindness towards the self (Neff, 2003). On the other hand, Self-criticism, as an inward-looking focus on the failure of the self, is less related to externally presented positive stimuli.

In correlation analysis, depressive symptoms were negatively, but weakly, related to the positive ratings of the Project Soothe pictures, as we would expect from the established

relationship between depression and reduced positive responding to positive stimuli (Dunn et al., 2004). Depressive symptoms were also negatively correlated with positive imagery vividness, again replicating previous findings (Morina, Deeprose, Pusowski, Schmid, & Holmes, 2011). However, our study extends these findings by indicating that the relationship between positive responding and Positive Imagery Vividness is itself independent of depressive symptoms. Indeed, it was surprising how low the standardised beta coefficients in the regressions were (none above .06), given that the level of depressive symptoms was quite high in our sample (17% met criteria for possible depression on the PHQ-9). This independent relationship between the positive variables echoes a recent finding that Positive Imagery Vividness predicts optimism even controlling for depression (Ji et al., 2017). Our study supports the view that positive variables are dissociable from psychopathology in predicting emotional responses.

An interesting question is whether the relationships found in the present study were trait- or state-like. Self-compassion and Self-criticism were explicitly measured as traits, so the effects involving these variables might be taken to indicate individual differences in dispositional emotional responding. The PHQ-9 depression scale asked individuals to reflect on their thoughts and behaviours over a period of two weeks, suggesting that it reflected current mood symptoms as opposed to the trait-level responses represented by Self-compassion and Self-criticism. The lack of a relationship for depression with positive responding in the multiple regressions may indicate that the observed relationships were more trait-level, and not influenced by current depressive symptoms.

Whether the imagery variables reflected stable individual differences or situational factors is unclear. On the one hand, the measure of Positive Imagery Vividness required participants to generate positive imagery there and then, perhaps making it sensitive to context, including the participant's mood state and experiences that day. On the other hand,

Positive Imagery Vividness is related to traits including Self-compassion in this study and optimism in previous studies (Blackwell et al, 2015; Ji et al, 2017), suggesting that it might also reflect trait-level individual differences. Nevertheless, Positive Imagery Vividness can be modified through training (Murphy et al., 2015), suggesting that it is not a fixed trait and can be a useful tool in psychotherapy (see below).

Our data relating to negative responding to Project Soothe pictures provide a useful insight into dysfunctional responding to positive stimuli. Negative Imagery Vividness and depressive symptoms showed stronger relationships with Anxious responding to the pictures than with the positive responding variables, suggesting that psychopathology was more associated with atypical negative responses to the positive stimuli than with reduced positive responses. Self-compassion, Self-criticism, and Age were also correlated with Anxious responses to the Project Soothe pictures, although effect sizes were small and Depression was the only significant predictor in the multiple regression model for Anxious responding when all factors were considered collectively. It is particularly interesting that Negative Imagery Vividness, which had the highest zero-order correlation with Anxious responding, had the lowest standardized beta coefficient of all the imagery/emotional disposition variables. This suggests that there was no specific relationship between negative mental imagery and dysfunctional *negative* responding to the positive stimuli *beyond* the general effect of depressive symptoms. This pattern of results suggests that the negative imagery measure captured the increased accessibility of negative information that is associated with depressive symptoms, and this negative bias related to increased negative responding to positive stimuli.

Project Soothe and Clinical Implications

The present findings are clearly informative for developing future interventions using Project Soothe pictures, but they also contribute more broadly to our understanding of

Positive Imagery Vividness as a clinically-significant predictor of emotional responses in three ways. Firstly, while previous studies have found that mental imagery vividness predicts response to interventions that aim to directly manipulate mental imagery (e.g. Blackwell et al., 2015), the current study suggests that this variable may predict clinical response in other contexts too, including therapies that use externally-presented positive stimuli. Secondly, this study probed the relationship between mental imagery and emotion using several measures of mental imagery and found that positive emotional responding was specifically related to the ability to construct vivid mental imagery from positive content, rather than a general tendency to have more vivid mental imagery. Previous studies (e.g. Blackwell et al, 2015) have not attempted to distinguish between these different explanations of the predictive power of mental imagery vividness. Thirdly, our study indicates that positive responding is relatively distinct from negative emotional tendencies. Such tendencies predict atypical anxious responses, but not reduced positive responses, to stimuli that people generally agree are positively-valenced.

The use of positive stimuli in therapy has been proposed (e.g. Hackmann et al., 2011), but has not received much empirical study. Project Soothe aims to create and scientifically validate a bank of images that could be used in future psychotherapy. The current study indicates that Positive Imagery Vividness may be a useful, easily assessable variable for predicting response to such stimuli, at least at baseline level. It might be that Positive Imagery Vividness is a moderator of outcome, with certain 'high imagery' individuals showing stronger responses to external stimuli, just as baseline mental imagery vividness predicts final response to imagery-based cognitive bias modification (Blackwell et al., 2015). Alternatively, an increase in Positive Imagery Vividness may mediate increased positive responding to external stimuli. A mediator of change would of course need to be modifiable, and there is evidence that Positive Imagery Vividness is; for example, a randomized

controlled trial found that a 4-week imagery intervention led to increased self-reported Positive Imagery Vividness (Murphy et al., 2015). It is also possible that Positive Imagery Vividness is not causally related to positive responding to external stimuli, but that both variables are indirectly related through a general positivity sensitivity – meaning that a positive imagery intervention would not necessarily boost positive responding to external stimuli. All the same, an intervention for depression simultaneously targeting mental imagery-based and perceptual representations may be more useful than one targeting just mental imagery, since depression involves *both* reduced positive responding to external stimuli (Dunn et al., 2004) and reduced Positive Imagery Vividness (Morina, Deeprose, Pusowski, Schmid, & Holmes, 2011).

Limitations and Future Directions

There are several limitations with this study. First of all, it used an opportunity sample that was self-selecting, which is a widespread issue with much research in psychology (Lönnqvist et al., 2007). Related to this, it is possible that the present data are confounded by a social desirability effect. An egoistic bias has been found in positive responding about mental imagery vividness (Allbutt, Ling, Rowley, & Shafiullah, 2011) and it is conceivable that this might have applied to the positive responses to the Project Soothe pictures in a related way. A self-report measure could be used in future to control for this (e.g. Balanced Inventory of Desirable Responding; Paulhus, 1998). Also, an order effect cannot be wholly ruled out, since the Project Soothe pictures were presented at the end of the protocol, though this was done to avoid mood induction effects. The current study focussed on positive stimuli, so it would be useful to investigate whether a similar valence-specific connection between mental imagery and emotional responding to stimuli also exists for negatively-valenced stimuli. Finally, this study was based on self-reported data. Therefore, future studies

might collect neuroimaging/ physiological data to provide a more objective measure of emotional response, and might use perceptual tasks to test whether individuals reporting vivid positive mental imagery perceive positive stimuli more vividly. We should not, however, underplay the importance of studying emotional experience by self-report, since this enables a greater understanding of how individuals subjectively access and respond to the emotional representations that occupy their conscious minds.

Conclusion

The present study presented novel findings that the strength of positive responding to positive stimuli is specifically related to the ability to construct positive, but not negative or neutral, mental images. This relationship provides evidence for individual differences in a single underlying positive processing tendency that operates across mental representations, whether they are simulated in the mind or based on current sensory input. Self-compassion also significantly predicted positive responding, indicating that trait level positive attitudes about the self are related to positive emotional experiences of affective stimuli, independently of the effect of positive mental imagery. It is notable that this positive processing tendency seems to be distinct from depressive symptoms and the negative response trait Self-criticism, which is of significant clinical interest. This study also considered negative responding to the positive stimuli, and found a very different result, with depressive symptoms uniquely explaining these atypical responses. In the wider context of Project Soothe, this study represents the first step in understanding the potential role soothing pictures may play in fostering positive emotions, potentially useful for future use in psychotherapy.

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Table 1

Descriptive Statistics and Spearman's Rank Order Correlations (two-tailed) for the study variables

	M	*SD*	2	3	4	5	6	7	8	9	10	11
1. Soothed	174.52	57.82	.80***	.70***	.24***	.19**	.30***	.06	-.14*	-.15*	.20**	.02
2. Happy	186.78	63.17		.79***	.18*	.27***	.40***	.03	-.19**	-.20**	.27***	.09
3. Excited	139.58	59.72			.34***	.28***	.41***	.11	-.12	-.12	.21**	-.05
4. Anxious	93.18	43.04				.02	.05	.33***	.29***	.25***	-.22**	-.20**
5. Gen. Vividness	56.53	12.32					.52***	.29***	-.05	-.16*	.21**	-.06
6. Pos. Vividness	31.87	8.76						.21**	-.34***	-.38***	.39***	-.04
7. Neg. Vividness	32.65	9.29							.43***	.43***	-.39***	-.29***
8. Depression	17.21	6.16								.67***	-.59***	-.25***
9. Self-criticism	35.77	15.12									-.80***	-.22**
10. Self-compassion	34.61	10.11										.19**
11. Age	27.03	11.66										

Note: Soothed, Happy, Excited, and Anxious refer to emotional responses to the Project Soothe pictures; Gen. Vividness = General Imagery Vividness; Pos. Vividness = Positive Imagery Vividness; Neg. Vividness = Negative Imagery Vividness.

*Correlation is significant at the .05 level. **Correlation is significant at the .01 level. ***Correlation is significant at the .001 level.

Table 2

Multiple regression with Happy response to the Project Soothe pictures as the criterion variable

	Model 1				Model 2			
	B	*SE B*	*β*	*p*	*B*	*SE B*	*β*	*p*
Age	.32	.37	.06	.394	.64	.37	.12	.089
Gender	13.14	9.18	.10	.157	16.88	8.77	.13	.057
Depression	-1.57	.80	-.15	.053	-.08	.89	-.01	.934
Gen. Imagery Vividness					.50	.45	.10	.278
Pos. Imagery Vividness					2.29	.67	**.32**	**.003**
Neg. Imagery Vividness					.30	.63	.04	.623
Self-criticism					.62	.49	.15	.218
Self-compassion					1.51	.68	**.24**	**.026**
Model R^2	R^2 = .042, **Adjusted R^2 = .028**				R^2 = .227, **Adjusted R^2 = .197**			
	F (3, 210) = 3.05, **p = .030**				F (8, 205) = 7.53, **p < .001**			
Change in R^2					**R^2 = .185**			
					F (5, 205) = 9.84, **p < .001**			

Note: **Bold** type indicates significance at the .05 level.

Table 3

Multiple regression with Excited response to the Project Soothe pictures as the criterion variable

	Model 1				Model 2			
	B	*SE B*	*β*	*p*	*B*	*SE B*	*β*	*p*
Age	-.45	.34	-.09	.168	-.17	.33	-.03	.595
Gender	-2.89	8.78	-.11	.744	-1.58	8.27	-.01	.854
Depression	-1.10	.74	-.02	.153	.54	.85	.06	.513
Gen. Imagery Vividness					.47	.42	.10	.273
Pos. Imagery Vividness					2.67	.65	**.39**	**<.001**
Neg. Imagery Vividness					-.36	.58	-.06	.529
Self-criticism					1.04	.47	**.26**	**.034**
Self-compassion					1.79	.69	**.30**	**.009**
Model R^2	R^2 = .016, Adjusted R^2 = .002				R^2 = .234, **Adjusted R^2 = .204**			
	F (3, 210) = 1.16, p = .327				F (8, 205) = 7.81, **p < .001**			
Change in R^2					**R^2 = .217**			
					F (5, 205) = 11.63, **p < .001**			

Note: **Bold** type indicates significance at the .05 level.

Table 4

Multiple regression with Soothed response to the Project Soothe pictures as the criterion variable

	Model 1				Model 2			
	B	*SE B*	*β*	*p*	*B*	*SE B*	*β*	*p*
Age	.03	.34	.01	.944	.27	.34	.05	.436
Gender	5.20	8.14	.04	.548	8.12	8.19	.07	.324
Depression	-.79	.76	-.08	.295	.19	.86	.02	.823
Gen. Imagery Vividness					.21	.41	.05	.613
Pos. Imagery Vividness					1.44	.69	**.22**	**.048**
Neg. Imagery Vividness					.51	.60	.08	.393
Self-criticism					.59	.47	.15	.220
Self-compassion					1.53	.62	**.27**	**.014**
Model R^2	R^2 = .009, Adjusted R^2 = -.005				R^2 = .123, **Adjusted R^2 = .088**			
	F (3, 210) = .646, p = .586				F (8, 205) = 3.58, **p < .001**			
Change in R^2					**R^2 = .114**			
					F (5, 205) = 5.30, **p < .001**			

Note: **Bold** type indicates significance at the .05 level.

Table 5

Multiple regression with Anxious response to the Project Soothe pictures as the criterion variable

	Model 1				Model 2			
	B	*SE B*	*β*	*p*	*B*	*SE B*	*β*	*p*
Age	-.33	.17	-.09	.059	-.17	.19	-.05	.375
Gender	-.31	5.81	-.00	.955	-.51	5.79	-.01	.931
Depression	1.82	.52	**.26**	**<.001**	1.78	.73	**.26**	**.016**
Gen. Imagery Vividness					-.34	.33	-.10	.306
Pos. Imagery Vividness					.99	.54	.20	.074
Neg. Imagery Vividness					.39	.44	.08	.395
Self-criticism					.54	.44	.19	.207
Self-compassion					.61	.61	.14	.317
Model R^2	R^2 = .089, **Adjusted R^2 = .076**				R^2 = .134, **Adjusted R^2 = .100**			
	F (3, 210) = 6.81, **p < .001**				F (8, 205) = 3.97, **p < .001**			
Change in R^2					R^2 = .045			
					F (5, 205) = 2.16, p = .060			

Note: **Bold** type indicates significance at the .05 level.

Appendix

Some examples of Project Soothe images used in the current study are shown below.